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PURIFICATION OF GASEOUS DISCHARGES OF RADIOACTIVE AEROSOLS AND GASES

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STATE CENTER FOR RADIATION PROTECTION

Report SZS-142

W. Ullmann, F. Schumann, R. Schwarzbach

PURIFICATION OF GASEOUS DISCHARGES OF RADIOACTIVE AEROSOLS AND GASES

S. Przyborowski

Studies of Filter Materials for Separating Aerosols from the Air of Nuclear Power Plants

R. Schwarzbach

Laboratory Studies on the Adsorption of Radio Iodine and Iodine Compounds on Active Carbon

H. Zindler

Determining the Emission of Radioactive Materials with the Exhaust Air of Nuclear Power Plants into the Air

F. Schumann

Retention of Krypton by Active Carbon (only a summary)

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State Central for Radiation Protection

SZS-142

Studies of Filter Materials for the Separation of aerosols from the Air of Nuclear Power Plants

By S. Przyborowski

Summary

The importance of a thorough testing of filter material used for the removal of aerosols from the exhaust air of nuclear power plants is pointed out. A method is presented for the assessment of penetration depending on particle size and flow rate. The results obtained are discussed.

1. Importance of the Material Testing

Fiber filters are used in nuclear power plants for the filtration of radioactive aerosols. The maximum obtainable protective effect is prescribed by the permeability of the filter material used. Thus, a thorough material testing must take place as the first stage in judging a filter.

For the Soviet filter material we find data from the manufacturer and the exporter concerning flow resistance and permeability. The so-called "standard resistance" refers to the flow rate of 1 cm/sec and is given in a water column. The permeability, expressed in %, refers to a flow rate of 1 cm/sec and a standard oil mist of 0.15 to 0.17 μ.

It is known that permeability is a function of flow rate and the particle size and exhibits a maximum for both dependences. These maxima correspond to the greatest danger and thus can serve as a basis for the safety considerations with the use of the filter. Since, however, the position of these maxima is different for each filter, no testing method can be built up which justifies the principle of optimum safety. Corresponding to the polydispersing character of the aerosols occurring in the nuclear power plants, the particle size dependence of the permeability is to be determined for a wide range of particle sizes. Also, the

dependence of the flow rate must be determined in a certain range by the flow rate which corresponds to normal throughput through the complete filter. Deviations from normal throughput occur in practice due to inaccurately adjusted venting systems, clogging of the filter, etc. The normal throughput through the complete filter often exhausts the maximum load of the filter material and thus in general lies above the standard rate of 1 cm/sec.

2. Method for Material Testing

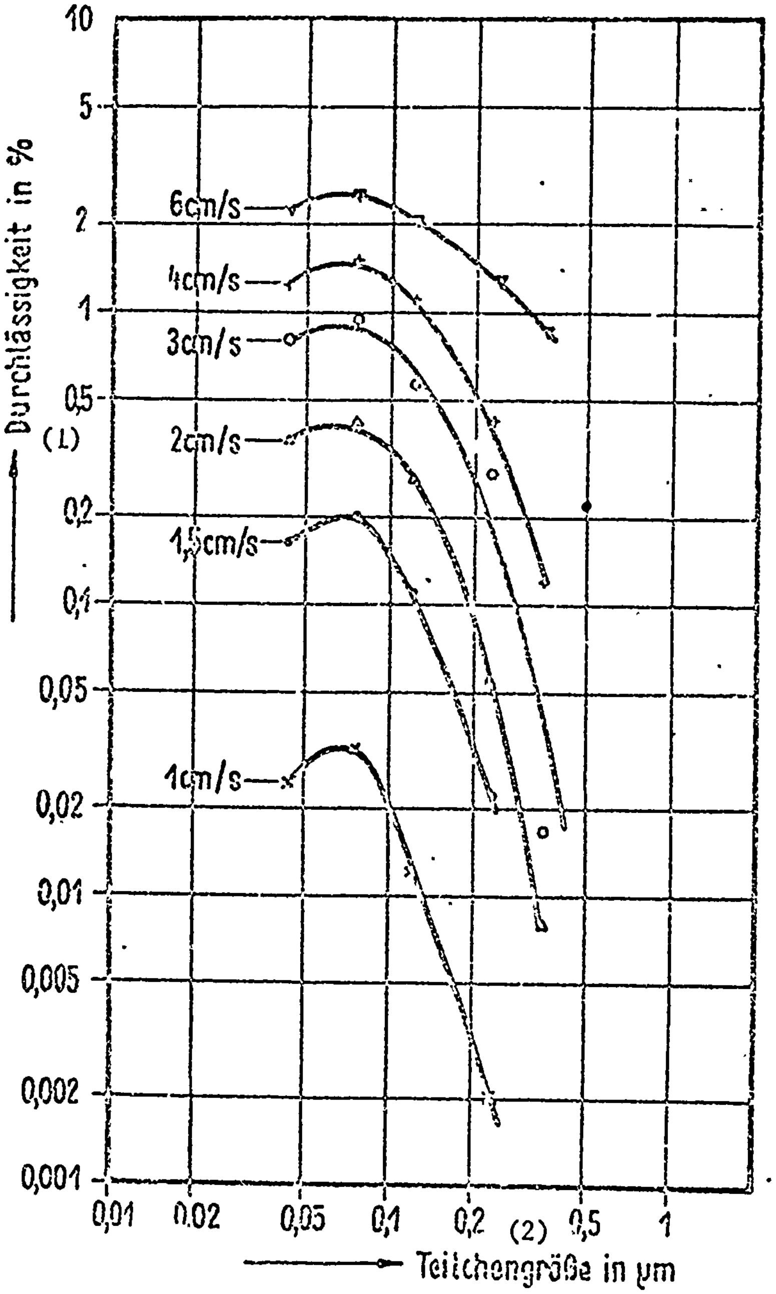
Two possibilities exist for the study of particle size dependence:

a) Monodispersed aerosol is used and its size is varied,

b) polydispersed aerosols are used and the particle size distribution is measured before and after the filter.

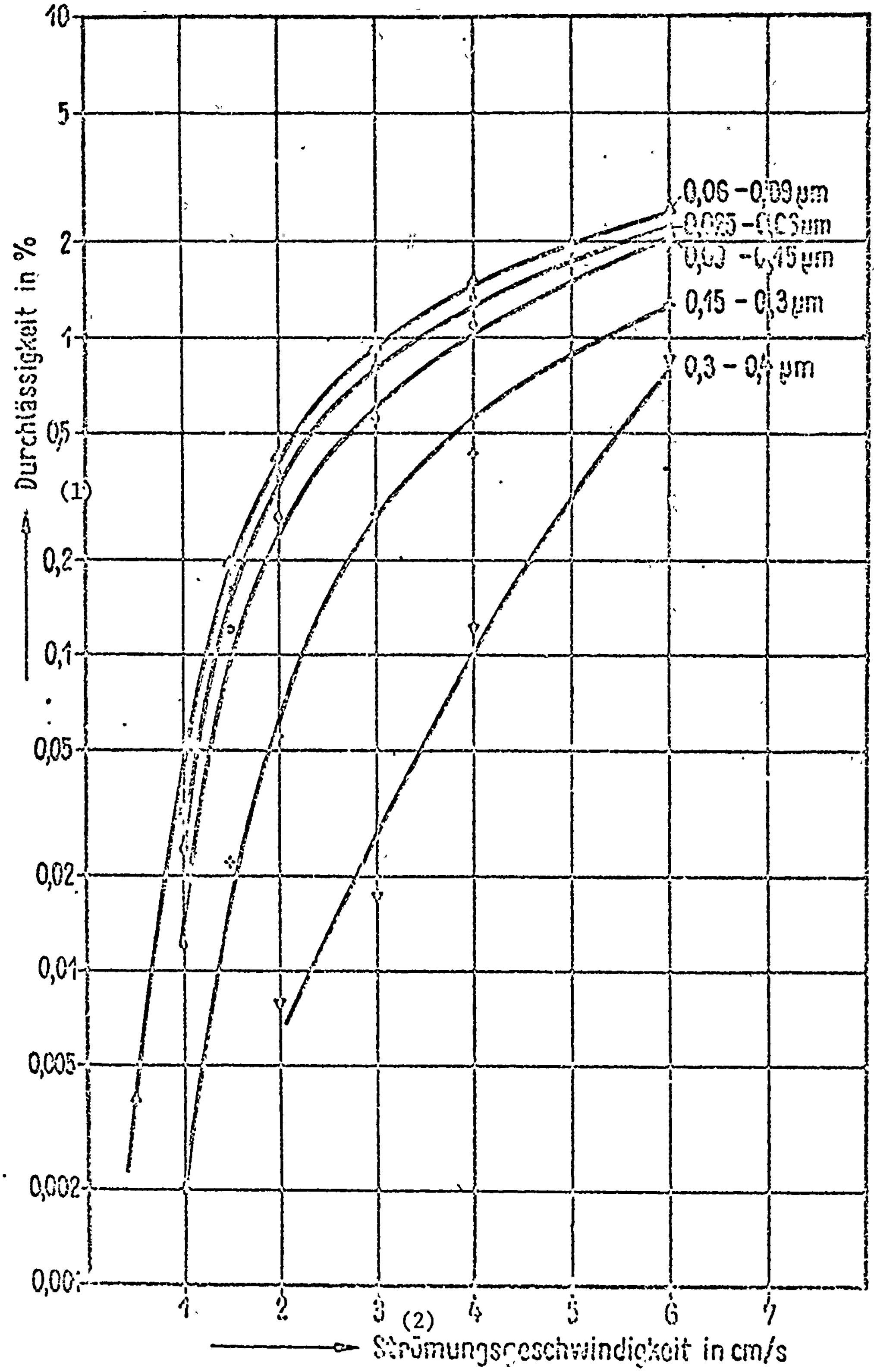
The first way is very tedious, since it presumes a new measurement for each particle size; in addition, the monodispersed aerosol with variable sizes and high concentrations, as they are needed for the testing of highly-effective filters, are realizable only with difficulty.

The second way is dependent on an aerosol measuring instrument, which makes it possible to measure the particle size distribution in the suspended state. Since even very finely-dispersed aerosols occur in the nuclear power plant, special value is to be laid on a high sensitivity in the submicron range. For this method we used the Sartorious scintillation particle counter (SST) for our method, which has a lower detection limit of 0.025 μm (for NaCl-particles). The SST is based on light emission from atom vapors stimulated in a hydrogen-air flame. If actually only 1 particle gets into the stimulation range of the flame, the result is particle-mass proportional light impulses which are converted in special amplifiers into a logarithmic or linear dependence of particle size. The equipment makes it possible for us to measure the particle size spectrum simultaneously in 10 channels and makes counting rates possible, which already with a few minutes measuring time lead to a high statistical sureness of the measuring results.



(1) Permeability in %. (2) Particle size in µm.

Fig. 1.--Percentage permeability for PPP-1.7 as a function of the particle size for different flow rates.



(1) Permeability in %; (2) Flow rate in cm/s.

Fig. 2.--Percent permeability for PPP-15-1.7 as a function of the flow rate for various particle sizes.

In the measurement of highly effective filters, we work with highly concentrated aerosols in order to arrive at statistically assured aerosol particle counts behind the filter. This highly concentrated aerosol is diluted in SST for the measurement. A rubber flask of 2 m^3 is presently used as an aerosol supply container, which in the future is supposed to be replaced by a spherical vessel made out of glass fiber reinforced polyester, in order to be able to reach higher pressures.

3. Results and Discussion

The first measurements were made already with the described method. The usability of the method is shown by the test results obtained for the Soviet filter material FPP-15-1.7. NaCl aerosol served as test aerosol. Fig. 1 shows the percentage permeability as a function of particle diameter (edge length of the NaCl-crystals) in log-log representation for various flow rates. The permeability maximum is obtained with an edge length of about 0.06-0.09 μm, thus essentially below the diameter for the standard oil mist. With still smaller particle sizes, the diffusion effect assumes significance and causes a decline of permeability. The decline of permeability to the right of the maximum is primarily to be attributed to the effect of electrostatic forces. At constant particle size, its influence is greater the lower the speed. It is worthy of note that even under the relatively narrow particle size range used here, the permeability coefficients extend over several orders of magnitude.

Fig. 2 shows the percent permeability as a function of the flow rate in semi-logarithmic representation for various particle size intervals. The range of 3 cm/sec was selected because it corresponds to the normal load of the filter material. With the used speeds, the maximum of permeability is not yet reached, i.e. these lower speeds do not suffice with the given particle sizes to lead to an essential separation due to inertia. In spite of the narrow speed ranges, changes in permeability also occur here by orders of magnitude.

The results show clearly that the standard speed of 1 cm/sec lies below, and the particle size of the standard oil mist lies above the maximum permeability. In both cases, thus, with knowledge of only these values, too small a permeability was simulated, i.e., too great a protective effect. Thus, we conducted a test of permeability as a function of the particle size and speed which we considered necessary. The method indicated here should thus serve, according to corresponding enlargement and improvement in the DDR, as a standard method for testing filter material intended for the filtration of ratioactiv aerosols.